

Climate Change and Increasing Frequency of Floods in the Kosi River Basin

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Abstract—This case study examines the changing nature of water resources in kosi river in Himalayas. As well as conflict of water rights between India and Nepal and failed attempts at hydropower generation, flood control measure and water catchment in dams. Since 1954 when agreement was signed between india and Nepal. relations have deteriorated infrastructure has stagnated, millions of people have been displaced by floods and could have been controlled by two nation works together. China is try to divert water from Tibet to downstream region that are rapidly developing in 21st century. Tibet autonomy issue is increases. it becomes more value able resource in term of water.

Keywords—water resources, flood control, hydropower generation, water catchment in dams, 1954 agreement with between India and Nepal

1. INTRODUCTION

Kosi and its several of important tributaries arun kosi from mount Everest in Tibet, tamur kosi in east and sun kosi further west. The Chinese tributary that flow into the kosi river finally turns flow into ganga river. Many dams and hydroelectric power facilities already exist on all of these. And several hydroelectric projects are planned for the future. A proposed project on Nepal's Bhote Koshi River may reduce downstream water availability, while offering a more reliable power supply to Kathmandu, the capital of Nepal. China, hydro projects on the tributaries of the Kosi pose threats of water shortages to downstream communities, but will provide stable power sources as well as means of flood control.

2. DURATION

Since the second half of the 20th century, flood control projects have been underway, but as the population in these regions continues to grow, concerns and conflicts over water availability and water level stability are increasing. With the region experiencing increasing warmth and dryness due to climate change, upcoming dam projects planned over the next two decades in upstream areas particularly by 2025. Pose significant risks to the water security of downstream population.

3. LOCATION

Nepal,
Bihar, India
Tibet, China

4 ACTORS

China's: Tibet region holds vast water resources, and China has shown a history of adopting aggressive water control measures that threaten the interests of downstream countries with little or no warning and very limited international dialogue. China has played a very limited role in international debates over water rights and resource governance. At home, the government faces immense political pressure to secure water supplies for its enormous population and to advance the ambitious South–North Water Diversion Project.

India: As a downstream nation with a vast population, India is profoundly affected by upstream actions, suffering the majority of flood-related deaths and economic losses.

Nepal: One of the world's poorest countries, Nepal continues to struggle with chronic infrastructure weaknesses especially in its water sector. Shockingly, only about one-quarter of its residents have access to safe, fully managed drinking water; the remaining two-thirds are left without reliable clean-water services.

5 ENVIROMENT ASPECTS

The Kosi Barrage, equipped with earthen dams spanning the river, was engineered with upstream and downstream embankments to force the river to flow within a fixed corridor. Downstream of the barrage, these embankments stretch for approximately 246 km (153 mi) to contain the river's shifting course. The primary objective of these embankments is to restrict the westward migration of the river. The embankments have been strategically spaced about 12 to 16 km apart to serve as effective silt traps and ensure proper regulation of flow. Constructed between 1959 and 1963 along the India–Nepal border, the Kosi Barrage was designed primarily for irrigation, flood protection, and generating hydroelectric power. It was undertaken under a bilateral agreement between Nepal and India, with the entire cost of the project borne by the Government of India. The catchment area of the Kosi River extends over 23,856 square miles in Nepal up to the barrage site. The world's highest mountain peaks lie within this catchment area, and approximately 10% of the Kosi's water flow is snow-fed, originating from glacial melt. The Eastern and Western canals originating from the barrage were designed to irrigate approximately 2.5 million acres of agricultural land. A 20 MW hydropower plant was constructed on the Eastern Canal, located 2.2 miles downstream from the barrage. The Western Kosi Canal irrigates nearly 62,000 acres of farmland in Nepal. Originating at the barrage, both the Eastern and Western canals were constructed to support approximately 2.5 million acres of agricultural land. On the Eastern Canal about 2.2 miles downstream from the barrage a 20 MW hydropower plant was established. The Kosi River and its main tributaries drain eastern Nepal and parts of Tibet, including areas around Mount Everest. Several tributaries begin in Tibet and merge into the Kosi roughly 30 miles north of the India–Nepal border. From there, the river flows south through the Siwalik Hills, cuts through the narrow Chatra Gorge, and enters the northern plains of India. Once it leaves the gorge, the Kosi enters Bihar's floodplain and heads toward the Ganges. Loaded with heavy sediment, it doesn't hold a steady channel across the plains. The river is infamous for sudden, massive floods water levels can surge up to 30 feet in just 24 hours making large swaths of north Bihar unsafe for farming or habitation for long stretches to mitigate these risks, a dam was built at Barahakshetra in the Chatra Gorge to manage floods, irrigate floodplains, produce hydropower, and support fish breeding facilities. The river basin's sandy soils are extensively used for cultivating maize (corn).

An alluvial fan is a cone-shaped deposit of sediments that forms when a river or stream flows out of mountainous terrain into a flat plain. As the water slows down, it deposits the sediments it carries.". the kosi alluvial fan cover nearly 6,000square mile

Flooding in Himalayan rivers is a natural phenomenon, but it is extremely dangerous and unpredictable. Rivers like the Kosi can suddenly become heavily laden with large volumes of water, which must pass through narrow valleys emerging from the world's highest mountains. Over the past 200 years, the main channel of the Kosi has shifted by several miles, as the river often spreads into its old channels during floods especially within this alluvial super fan region (highlighted area in Orange below).

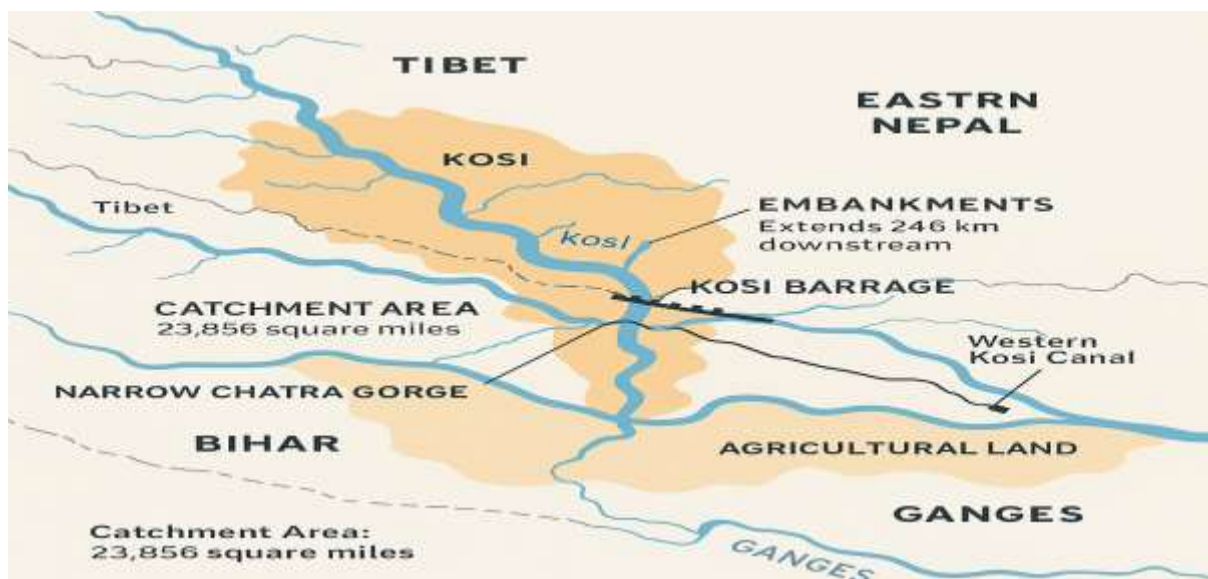


Figure1. Detailed map illustrating the Kosi River Basin, highlighting the barrage, protective embankments, irrigation canals, and flood-affected zones in Nepal and Bihar



Figure 1 ,Kosi River Alluvial Fan: Satellite view showing the vast alluvial fan formed by sediment deposition, confined by embankments on both sides to control the river's shifting course.

As a result, massive flooding occurs over fertile agricultural lands, causing severe loss of life, property, and crops.

A dam that was neglected for decades by both Nepal and India, along with the failure of a partnership for a second dam, likely led to the catastrophic flood of 2008, which displaced over 3 million people. The severity of this flood can be attributed, to some extent, to the poor maintenance of man-made embankments that were built to control the river but failed during the massive flood.

This illustrates how dangerous excessive reliance on flood control projects can be, as they create a false sense of security and encourage people to settle in areas that were previously left as floodplains for the drainage of monsoon rains. In a region where the demand for food is very high, leaving fertile land areas like the Kosi alluvial fan unused—despite the severity of flood risks is a very difficult decision

In Nepal, a dam that was neglected for decades by both Nepal and India, along with the failure of a proposed partnership for a second dam, likely led to the devastating flood of 2008, which displaced more than 3 million people.

Agricultural land submerged after the devastating Bihar flood of 2008, when the Kosi River breached its embankments and flooded most of the Kosi alluvial superfan.



Figure 2 Inundated farmland after the 2008 Bihar flood, when the Kosi River breached its embankments and submerged large parts of the Kosi alluvial fan.

6 Climate change

As the climate continues to warm, glacial melting will increase, which will also raise the risk of Glacial Lake Outburst Floods (GLOFs) that can overwhelm existing flood control measures. In 1988, a study led by a Chinese and Nepalese team surveyed all the glacial lakes that could drain into the Kosi River basin. Out of 229 lakes, several dozens were already identified as dangerous even back in 1988. Throughout the 20th century, glacial lake outburst floods (GLOFs) became increasingly common. At the 2010 Himalayan Summit, experts identified 82 glacial lakes as posing immediate threats to downstream communities' livelihoods.

A warming climate also means that some lower elevation areas will lose their permanent snow cover and sources of fresh water, while other regions will experience increased glacial melt, raising the risk of flooding during the monsoon season — along with more intense rainfall. In the Tibet region, a drying trend has been projected, which will largely depend on the severity of drying in the neighbouring Mediterranean region. Due to the region's high and uneven topography, making broad forecasts is difficult; however, the strong drying trends observed in spring, summer, and autumn are partially offset by increasing winter precipitation. (IPCC Report). In interior regions that rely on glacier-fed rivers, water supply will become less reliable in the future. By the year 2050, glaciers will still be present in the region, but due to warmer and drier summers, they will have retreated significantly, resulting in a decline in late-summer river runoff. Therefore, during the monsoon summer season, the source of river flow will now depend more heavily on the inconsistent and intense monsoon rains compared to earlier times.

Satellite view from the year after 2008 flood. Left side shown initial physical features and water way before 2008 flood and right side. figure shown change the path of water after the flood 2008.



Figure 3, Satellite imagery reveals dramatic shifts in the Kosi River's course following the 2008 flood a consequence of intensified monsoon activity and accelerated glacial melt linked to climate change

7 Type of Habitat

Subtropical highland, warm temperate, humid subtropical, and cool semi-arid zones make up the region. The amount and timing of annual rainfall are largely dependent on the East Asian monsoon. Most of the rainfall occurs during the summer months throughout the entire region.

8 Act and Harm Sites

The plains of Bihar, where severe flooding remains a constant threat due to the lack of effective flood control measures.

Nepal is tapping into its vast hydropower potential and planning future projects—which raise serious concerns for India's water claims, especially regarding the maintenance of steady water flow to Bihar during the dry season

9 Type of Conflict

Civil and international: There are internal civil conflicts within China, particularly concerning the North-South Water Diversion Project, and in Nepal as well, over the trade-off between the benefits of flood control and power generation versus the potential environmental damage.

Throughout much of its history, China has been a dominant power (hegemon) in the region, maintaining relative peace, although its control over the Tibetan region has always been contentious. Today, this region

is especially important for its abundant water resources. Stretching from Nepal to China's border, the Himalayas and Tibetan Plateau are commonly called the 'Water Tower of Asia.' This area ultimately supplies freshwater to over one-third of the global population—serving India, China, Nepal, and multiple Southeast Asian countries reliant on the Mekong River system. The Mekong originates on the Tibetan Plateau and flows through Laos, Thailand, Cambodia, and Vietnam

China's Power Strategy: Potential upstream/downstream international conflicts may arise when water diversion or infrastructure projects in upstream countries alter or disrupt freshwater availability for downstream communities. In this case, China is typically the upstream country and India is the downstream party, making India dependent on China's political will. China often operates under the principle that it can do as it pleases within its own territory, although it occasionally tries to acknowledge potential downstream impacts. A common tactic in such situations is to downplay potential conflict by claiming that many of its projects are still only at the planning stage (Tibetan Waters: A Source of Cooperation or Conflict?).

The immense populations of both China and India, along with their already tense relations, play a major role in hindering cooperation, as both nations have high water demands and are governed under incompatible political systems, making collaboration and coordination extremely difficult.

10 Level of Conflict

Variable: For Nepal, hydropower holds the potential for immense wealth and political influence, but this promise is offset by dams that displace villages and agricultural land. A major point of conflict exists between Nepal and the Indian border state of Bihar. It is here, along the flow of the Kosi River, that issues of water rights come into focus

Since the Kosi Agreement was signed in 1954 for flood control, dialogue between India and Nepal has largely remained stalled, leaving numerous grievances unresolved.

11 Fatality Level of Dispute (military and civilian fatalities)

2008 Bihar Flood: 450 civilian deaths

In the future, the fatality rate due to violent conflicts is likely to remain low, but millions of people may be displaced — whether due to resettlement for dam projects, damage caused by floods, or a shortage of potable water.

12 Level of Strategic Interest

Regional: This conflict requires careful diplomatic relations among the three involved parties, and transparency in the process will be critically important.

13 Outcome of Dispute

It is likely that tensions between the involved countries will increase. Between now and the year 2050, there is a relatively higher possibility of small-scale violent conflicts. If everything continues as it is, China a

rapidly emerging global power is likely to dominate the region and gain full control over the water resources it desires.

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